

## SPIN FORMING OF HVAC DUCT REDUCERS

### CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Application  
5 No. 60/408,471, filed September 4, 2002.

### FIELD OF THE INVENTION

The present invention relates to conical fittings used in heating, ventilation and air  
conditioning (HVAC) ducting systems, and more particularly to the spin and roll forming  
of conical reducers, conical taps, wye fittings and similar conical fittings used in HVAC  
10 ducting.

### BACKGROUND OF THE INVENTION

Conical reducers are commonly used in HVAC ducting to serve as a transition  
between a larger diameter duct and a smaller diameter duct. The conical reducer can be  
joined between an end of a larger size diameter or duct and the adjacent end of a smaller  
15 diameter duct. Also, conical fittings can be used to intersect a larger diameter duct in a  
direction transversely to the length of the larger diameter duct. For this purpose, conical  
taps and saddle taps are typically used. Further, wye fittings can be used to connect two  
smaller diameter lines to the end of a larger diameter line, with the two smaller diameter  
lines being angularly disposed relative to each other.

20 Such conical fittings typically have been formed from a flat pattern that is then  
rolled to form a conical shape and welded along a seam. Collar sections are then welded,  
riveted or otherwise attached to the smaller end portion of the conical fitting, and also  
sometimes to the larger end portion of the conical fitting. This is a slow, labor intensive  
process causing the conical fittings to be relatively expensive to manufacture.

Moreover, current manufacturing techniques limit the gauge of material used to form the conical reducers to about 22 gauge. It would be advantageous if thinner gauge material, perhaps down to 26 gauge, could be used for conical fittings thereby reducing the weight and cost of such fittings. The present invention addresses the foregoing  
5 shortcomings of existing methods of manufacturing conical fittings by incorporating spin forming techniques.

## SUMMARY OF THE INVENTION

The present invention concerns methods of forming conical connectors for use in HVAC ducting. Such connectors may be manufactured by placing a conically shaped  
10 workpiece of thin gauge metallic material into a spin die, with the spin die having at least one cylindrical surface or shoulder. The conically shaped workpiece is spun about its longitudinal central axis and a work tool used to form the workpiece as it is spinning to conform the workpiece to the shape of the cylindrical surface of the spin die, thereby to form a collar portion at at least one end of the conical fitting. The spin die can be formed  
15 with two cylindrical surfaces thereby to form collar portions at each end of the conical fitting.

In accordance with a further aspect of the present invention as the workpiece is spinning, a forming tool is used to press the workpiece against the cylindrical surface of the die, thereby to match the shape of the workpiece directly to the shape of the die.

20 In accordance with a further aspect of the present invention, the spin die is positioned within the workpiece before the workpiece is formed.

In accordance with another aspect of the present invention, the workpiece is positioned within the spin die prior to the workpiece being formed.

In an additional aspect of the present invention, a mating flange is formed at at  
25 least one end portion of the conical connector. This is accomplished by expanding the end portion of the workpiece as the workpiece is being spun to form a generally annularly shaped mating flange that extends generally transversely to the longitudinal central axis of the workpiece.

As another aspect of the present invention, a hem section is formed from the outer  
30 perimeter portion of mating flange while the workpiece is spinning. This is accomplished by forming the outer perimeter portion of mating flange to extend away from the surface

of the mating flange to position generally concentrically to the longitudinal axis of the workpiece.

As another aspect of the present invention, return flange is formed by turning a portion of a hem section located distally from the mating flange over on itself as the  
5 workpiece is rotating.

## BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same become better understood by reference to  
10 the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a depiction of the starting shape of the workpiece for a conical reducer manufactured by use of the present invention;

FIGURE 2 is a side elevation depiction of the flat workpiece of FIGURE 1 rolled  
15 or otherwise formed into a frustoconical shape;

FIGURE 3 is a cross-sectional view of the frustoconical workpiece of FIGURE 2 with forming die or jig disposed within the interior of the conical workpiece prior to the workpiece being spun formed;

FIGURE 4 is a completed conical reducer that has been spun formed;

20 FIGURE 5 is a cross-sectional view of a generally frustoconical workpiece shown as inserted within the interior of a forming die, with the lower portion of FIGURE 5 showing the workpiece prior to being spun formed, and with the upper portion of FIGURE 5 showing the workpiece being formed during spinning of the workpiece;

FIGURE 6 is a completed conical reducer that has been spun formed using the die  
25 shown in FIGURE 5;

FIGURE 7 is a workpiece having spun formed collars as engaged with a collar die used in conjunction with forming a flange connector at the larger end portion of the conical fitting;

FIGURE 8 illustrates the workpiece of FIGURE 7, as partially formed to create a  
30 mating flange that extends transversely to the longitudinal axis of the workpiece;

FIGURE 9 shows the workpiece of FIGURE 8, further formed to create a hem portion against exterior surface of the collar die;

FIGURE 10 illustrates a further embodiment of the present invention wherein a conical connector formed with a collar section at its smaller end portion is engaged with a collar die at its larger end portion to form a flange connector thereat;

FIGURE 11 shows the workpiece of FIGURE 10 wherein a mating flange has  
5 been formed against the adjacent end portion of the collar die and with the outer perimeter portion of the mating flange turned partially down in the direction away from the mating flange;

FIGURE 12 shows the workpiece of FIGURE 11, further formed with a hem section bearing against the outer surface of the collar die and with a return section  
10 extending transversely from the hem section;

FIGURE 13 shows the workpiece of FIGURE 12, wherein the return portion has been pressed downwardly against the outer surface of the hem;

FIGURES 14, 15, 16, 17, 18 and 19 illustrate an alternative method of forming a flange connector at the end of the conical fitting of the present invention; and

FIGURES 20, 21, 22 and 23 illustrate a further alternative method of forming the  
15 present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention relates to a method for spin forming conical reducers,  
20 conical taps, and other types of connectors, especially reducing connectors, used in HVAC ducting. The present invention can be used down to at least 26-gauge steel metal material, whereas prior art methods of forming conical reducers were limited to about 22-gauge steel metal material.

In accordance with the present invention, a workpiece flat 10, as shown in  
25 FIGURE 1, is cut, stamped or otherwise formed from flat sheet stock or roll stock. The flat workpiece of FIGURE 1 is rolled or otherwise formed into the frustoconical shape shown in FIGURE 2 to define small diameter end 16 and larger diameter end 18. The mating edges 12 and 14 of workpiece 10 are welded or otherwise locked/connected together along a seam 20.

30 A forming die or jig 22 is placed within the interior of the frustoconical workpiece. The forming die may include a smaller, substantially constant diameter disk portion 24 having an outside diameter approximating the inside diameter of small end 16

and a larger, substantially constant diameter disk portion 26 somewhat smaller than the maximum interior diameter of the large end 18 of the frustoconical workpiece. The disk portions 24 and 26 define generally cylindrically shaped die surfaces that are concentric with the longitudinal, central axis 30 of the die. The disk portions 24 and 26 of the die 22  
5 may be connected by a central hub 28 to form a unitary member. The die is held relative to the workpiece by any convenient method, such as by use of clamps, not shown. The die, 22, together with the workpiece 10, is adapted to being spun at relatively high speeds about longitudinal axis 30 (up to at least several hundred RPM), for example by coupling the die to a powered shaft or lathe spinning machine or other equipment. See for example  
10 the spinning machines disclosed in U.S. Patent No. 5,983,496, incorporated herein by reference.

The forming die 22 can be designed in such a way to accommodate conical reducers of various sizes and of various reductions. In this regard, the disk portions 24 and 26 can be replaced with disk portions of other diameters as well as other thicknesses.  
15 Moreover, the central hub 28 can be of various lengths. In this matter, the forming die 22 can be very versatile and used to construct conical reducers of many different configurations.

A forming tool 32 is pressed against the outer diameter of workpiece 10 over the area of the small diameter disk portion 24 to form a small diameter collar portion 38. The  
20 same or a different work tool is placed over the larger diameter end portion of the workpiece over the location of the larger diameter disk 26 to form the workpiece against the disk, thereby to create a larger diameter, cylindrical collar section 40 at the end of the workpiece opposite the smaller diameter, cylindrical collar portion 38 and thereby arrive at a completed conical reducer 41. It can be appreciated that the cylindrical collar  
25 portions 38 and 40 are sized to engage within or over the adjacent end portions of circular ducting, not shown.

Although the present invention has been described in conjunction with the manufacturer of a conical reducer, the present invention may also be used to form other HVAC ducting components, for example, conical taps, conical tee reducers, die fittings,  
30 and other fittings in which a reduction in the diameter of the fitting occurs.

It will be appreciated that, rather than utilizing a die 22 that is positioned inside of the workpiece 10, a different die may be utilized that engages over the exterior of the

conical-shaped workpiece. Such die may be of a first size to engage over the small end portion 16 of the workpiece and then a forming tool, such as tool 32, can be pressed against the inside diameter of the workpiece to force the workpiece outwardly against the exterior die to form a collar portion. Likewise, a larger diameter exterior die can be placed over the larger end portion 18 of the workpiece and then a forming tool used to press the workpiece outwardly against such die to form a collar portion. It will also be appreciated that an interior-type die may be used with one end portion of the workpiece and an exterior-type die used with the opposite end of the workpiece, so as to form the ends of the workpiece into substantially constant diameter collar portions.

FIGURE 5 shows an alternative embodiment of an exterior forming die 42 which is designed to be spun about a longitudinal axis 44. The interior of die 42 is shaped to correspond to the exterior of the finished conical reducer 41' shown in FIGURE 6. To this end, the interior of the die 42 has a first interior cylindrical die surface 46 of substantially constant diameter and concentric with longitudinal axis 44. The interior of the die, at the opposite end thereof, has a second smaller diameter cylindrical die surface 48 which is of substantially constant diameter and concentric with longitudinal axis 44. The width of the die surfaces 46 and 48 correspond to the width of the cylindrical collar portions 38' and 40' shown in FIGURE 6. Between the die surfaces 46 and 48, the interior 49 of the die 42 is tapered to match the taper of the central portion 50 of the conical reducer 41'.

To form the conical reducer 41' a workpiece, such as workpiece 10 shown in FIGURE 2, is snugly placed within the interior of the die 42, to assume the position shown in the lower portion of FIGURE 5. The workpiece may be securely held in place within the die by any convenient means. Thereafter, the die is spun about axis 44 and a forming tool 32' is positioned within the workpiece adjacent die surface 48 to force the adjacent portion of the workpiece against the surface 48 thereby to form collar portion 38'. A forming tool 52 is positioned within the interior of the workpiece and is pressed outwardly against the portion of the workpiece adjacent die surface 46 so as to force the workpiece against the die surface as the workpiece is rapidly spinning thereby to form the larger diameter collar section 40'. It will be appreciated that the forming tool 52 may have a sharper edge so as to be able to force the workpiece into the interior corner defined by the intersection of die surface 46 and central die portion 49. The same

forming tool 52 may be used in place of forming tool 32' if it is desired to use the same forming tool at both ends of the workpiece. Thereafter, the formed conical reducer 41' may be simply slid off the die 42 in the left hand direction shown in FIGURE 5. It will be appreciated that the completed conical reducer 41' can be substantially the same as the  
5 conical reducer 41 shown in FIGURE 4.

The conical reducers 41 and 41' can be engaged within or over the adjacent end portions of circular ducting, not shown. Alternatively, the conical reducers may be further formed to create a flange connector at one or both of its ends that complies to the T24 or other flange profile of the Sheet Metal and Air Conditioning Contractors National  
10 Association (SMACNA).

One method of forming a flange connector to a conical reducer is shown in FIGURES 7, 8 and 9. The workpiece 60 is formed with a collar portion 62 at the larger diameter end thereof using one of the methods described previously. The workpiece is placed within a collar die 64 which is positioned along the conical portion 66 of the  
15 workpiece 60 adjacent the collar portion 62. The collar die is adapted to be spun about longitudinal axis 68 by any convenient means. The collar portion 62 may be formed against the end surface 70 of the collar die using various techniques, including those described in U.S. Patent Nos. 5,983,496 and/or 6,289,706 so that the collar portion is worked into the orientation shown in FIGURE 8, thereby to create a mating flange 72.

One example of how the collar portion 62 may be formed from the position shown in FIGURE 7 to position shown in FIGURE 8 is through the use of a forming tool similar to tools 32 or 52'. That same tool can then be applied against the portion of the mating flange 72 that extends beyond the diameter of the collar die 64 to bend the outer  
20 perimeter portion of the mating flange over against the exterior surface 74 of the collar die to form a hem portion 76, shown in FIGURE 9. Thereafter, the collar die may be removed from the formed workpiece by sliding the collar die in the right-hand direction, shown in FIGURE 9 relative to the workpiece.

FIGURES 10, 11, 12 and 13 illustrate a further embodiment of the present invention wherein a flange connector is formed at one end of a workpiece 80 without a  
30 collar section first being formed in the conical reducer workpiece. FIGURES 10-13 correspond to generally the top portion of FIGURES 7, 8 and 9. As shown in FIGURES 10-13, the workpiece 80 includes a collar portion 82 formed at the smaller

diameter end of the conical reducer to form the connector flange. A collar die 84 is placed over the workpiece 80 adjacent the larger diameter end of the workpiece. The workpiece is snugly held in engagement with the collar die by any convenient means. The collar die is spun about longitudinal axis 86 of the workpiece in the manner described above with respect to other embodiments of the present invention. A forming tool, which can be similar to tools 32 and 52, described above, may be utilized to form the portion 88 of the workpiece 80 that extends beyond the collar die 84. As shown in FIGURE 11, the extending workpiece portion 88 is first pressed against the adjacent end 90 of the collar die to form a mating flange 92. The portion of the mating flange 92 that extends radially beyond the collar die is then folded over toward the outer surface 94 of the collar die. The workpiece is further formed to create a hem portion 95 and a further portion 96 that is folded over the hem portion to form a return portion, as shown in FIGURE 13. It will be appreciated that the completed connector 97 can be used to connect the conical reducer to a T-24 or other profile flanged ring installed at the end of an adjacent duct or fitting.

Also, rather than forming the connector 97 at the larger end of the workpiece 80, a similar connector can be formed at the smaller diameter end of the workpiece using techniques similar to that described.

FIGURES 14-19 illustrate an alternative to the foregoing described methods for producing a flanged connector for a conical reducer 100. In this alternative method, an exterior mating flange 104 can be spin formed as described above. Thereafter, the hem section 105 can be formed by a first roller set 200 consisting of a first roller assembly 202 composed of a major diameter roller 204 and a side-by-side smaller diameter roller 206, both mounted on a rotatable shaft 208. The first roller set 200 also includes a second roller assembly 210 consisting of a roller 212 mounted on a rotatable shaft 214. The rotatable roller shafts 208 and 214 may be moved towards and away from each other in a substantially parallel orientation in a well-known manner. When the shafts are moved toward each other, the roller 212, positioned at the side of roller 204, forms the exterior and interior hem section 105, by capturing the hem section between the adjacent face sections of the rollers 204 and 212. In addition, a precursor to the return flange 106 may be formed between the outer diameter of roller 212 and the outer diameter of roller 206. See FIGURE 15 wherein a hem section 105 extends substantially laterally and optionally



perpendicular to a mating flange 104 and the precursor to the return flange 106 extends substantially perpendicular to the adjacent end of the hem section.

The partially formed Flanged Ring 100 of FIGURE 15 may be placed in a roller set 220 of FIGURE 16 for further processing. The roller set 220 includes a die roller assembly 222 composed of a die roller 224 mounted on a rotatable shaft 226. The die roller 224 may have a groove formed around its outer perimeter in the shape of a half "V" composed of a vertical face 228 and a diagonal face 230. The roller set 222 may include a second roller assembly 232 composed of a cylindrical roller 234 mounted on a rotatable shaft 236. The roller assemblies 224 and 232 are capable of moving towards and away from each other while the rotatable shafts 226 and 236 remain substantially parallel to each other. As shown in FIGURE 16, the partially formed flanged connector 100 from FIGURE 15 is positioned relative to roller 224 so that hem section 105 is adjacent vertical face 228 of roller 224. Thereafter, the roller sets 222 and 232 may be moved towards each other as the rollers 224 and 234 rotate relative to each other thereby causing the return flange section 106 to assume the orientation of roller face 230 relative to roller face 228, as shown in FIGURE 17.

Thereafter, the flanged connector in the configuration of FIGURE 17 may be further formed by roller set 240 shown in FIGURE 18. Roller set 240 consists of a pair of roller assemblies 242 and 244 each composed of a roller 246 and 248 carried by a corresponding rotatable shaft 250 and 252. As shown in FIGURE 18, the hem section 105 and the partially formed return flange 106 may be placed between the two rollers 246 and 248 and then the two rollers are moved relatively towards each other while rotating, thereby to pinch the hem section and return flange therebetween so that the return flange closely overlies the hem section and thereby completing the formation of the flanged connector 100', as shown in FIGURE 19.

FIGURES 20-23 illustrate another method of forming a flanged connector 100' for a conical reducer in accordance with the present invention. As illustrated, the exterior mating flange 104' of the flanged connector 100' may be formed using a spin forming method, such as described above. Thereafter, the outer marginal portion of the mating flange may be placed in roller set 300 to partially form each hem section 105' and return flange 106', as shown in FIGURE 21. The roller set 300 may include a first roller assembly 302 consisting of a roller die 304 mounted on the rotatable shaft 306. A "V"

shaped groove 308 extends around the circumference of the roller die 304 to match the outer perimeter profile of a roller die 310 mounted on rotatable shaft 312 of a roller assembly 314. The roller assemblies 302 and 314 are capable of moving towards and away from each other while their respective shafts 306 and 302 rotate and maintain an orientation substantially parallel to each other. As a consequence, when the outer marginal portion of the exterior mating flange 104' is placed in alignment with groove 308 and then the roller dies 304 and 310 rollably engage with each other they cooperatively form hem section 105' and return flange 106' in the orientation shown in FIGURE 21.

10           Thereafter, the partially formed flanged connector shown in FIGURE 21 may be further worked by roller set 340 shown in FIGURE 22. The roller set 340 corresponds to the roller set 240 shown in FIGURE 18, with the description set forth above with respect to FIGURE 18 applying to FIGURE 22, but with the part numbers increased by 100. Thus, such description will not be repeated. The result of roller set 340 is a finished  
15   flanged connector 100' as shown in FIGURE 23.

          It will be appreciated that other combinations of roller sets could be utilized to form the hem section and return flange of the flanged connector, other than as illustrated above in FIGURES 14-23. Although use of such rolling techniques may not be as efficient as spin forming the entire flanged connector in the manner described above,  
20   utilizing rolling processes may enable the flange ring to be manufactured with less expensive tooling or with tooling already on hand as opposed to requiring extensive spin form tooling.

          While the preferred embodiment of the invention has been illustrated and described, it will be appreciated that various changes can be made therein without  
25   departing from the spirit and scope of the invention.